

Revision Sheet

A-Level Physics · Unit 23 Nuclear physics

7 vocabulary items · 38 marks of exam questions (4 questions)

Part 1 · Vocabulary review (7 items). The terms this unit is examined on most. Mark it yourself from the answer key.

Section A · Chinese to English

Write the English word.

- | | | |
|----|-------|-----|
| 1. | _____ | [1] |
| 2. | _____ | [1] |
| 3. | _____ | [1] |
| 4. | _____ | [1] |
| 5. | _____ | [1] |
| 6. | _____ | [1] |
| 7. | _____ | [1] |

Part 2 · Exam questions (38 marks, 4 questions) begins on the next page. They are ordered easy to difficult and none of them has been set before.

- 8 (a) Define radioactive *decay constant*.

.....
.....
..... [2]

- (b) A sample of radioactive iodine-131 ($^{131}_{53}\text{I}$) of mass $5.87 \times 10^{-10} \text{ kg}$ has an activity of $2.92 \times 10^9 \text{ Bq}$.

Determine the decay constant of iodine-131.

decay constant = s^{-1} [3]

- (c) Suggest **two** reasons why a detector placed near to the sample in (b) would record a count rate much less than 2.92×10^9 counts per second.

1.
.....
2.
..... [2]

[Total: 7]

9 (a) State what is meant by nuclear fusion.

.....

.....

..... [2]

(b) On Fig. 9.1, sketch the variation of binding energy per nucleon with nucleon number A for values of A between 1 and 250.

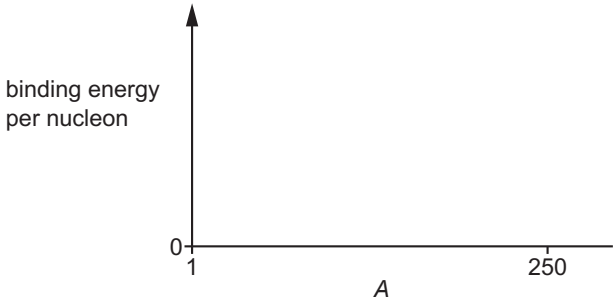


Fig. 9.1

- (c) On your line in Fig. 9.1, label:
- (i) a point X that could represent a nucleus that undergoes alpha-decay [1]
 - (ii) a point Y that could represent a nucleus that undergoes nuclear fusion. [1]

(d) A nucleus Z undergoes nuclear fission to form strontium-93 ($^{93}_{38}\text{Sr}$) and xenon-139 ($^{139}_{54}\text{Xe}$) according to

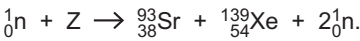


Table 9.1 shows the binding energies of the strontium-93 and xenon-139 nuclei.

Table 9.1

nucleus	binding energy / J
$^{93}_{38}\text{Sr}$	1.25×10^{-10}
$^{139}_{54}\text{Xe}$	1.81×10^{-10}

The fission of 1.00 mol of Z releases 1.77×10^{13} J of energy.

Determine the binding energy per nucleon, in MeV, of Z.

binding energy per nucleon = MeV [4]

[Total: 10]

10 Carbon-15 ($^{15}_6\text{C}$) is an isotope of carbon that undergoes radioactive decay to nitrogen-15 ($^{15}_7\text{N}$), which is a stable isotope of nitrogen.

Radioactive decay is both a random and a spontaneous process.

(a) State what is meant by:

(i) random

.....
 [1]

(ii) spontaneous.

.....
 [1]

(b) A small sample of carbon-15 decays. The mass M of carbon-15 in the sample decreases with time t .

Fig. 10.1 shows the variation with t of the value of $\ln (M/10^{-16}\text{g})$.

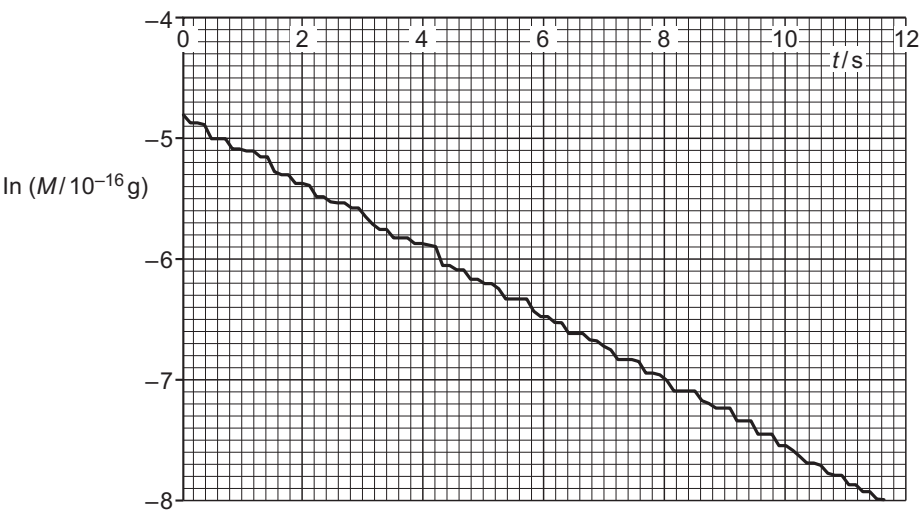


Fig. 10.1

(i) State how Fig. 10.1 demonstrates that radioactive decay is random.

.....
 [1]

(ii) On Fig. 10.1, draw the straight line of best fit.

[1]

(iii) Show that the decay constant λ of carbon-15 is given by the magnitude of the gradient of your line in (b)(ii).

[1]

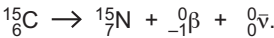
(iv) Use your line in (b)(ii) to determine λ . Give a unit with your answer.

$\lambda =$ unit [2]

(v) Use your answer in (b)(iv) to calculate the half-life of carbon-15.

half-life = s [1]

(c) The equation for the decay of carbon-15 can be written as



State and explain how the mass of the products of the decay must compare with the mass of the carbon-15 nucleus.

.....

 [2]

[Total: 10]

11 (a) State what is meant by radioactive decay.

.....

.....

..... [2]

(b) A radioactive sample consists of an isotope X of half-life T that decays to form a stable product. Only X and the stable product are present in the sample.

At time $t = 0$, the sample has an activity of A_0 and contains N_0 nuclei of X.

(i) On Fig. 10.1, sketch the variation with t of the number N of nuclei of X present in the sample. Your line should extend from time $t = 0$ to time $t = 3T$.

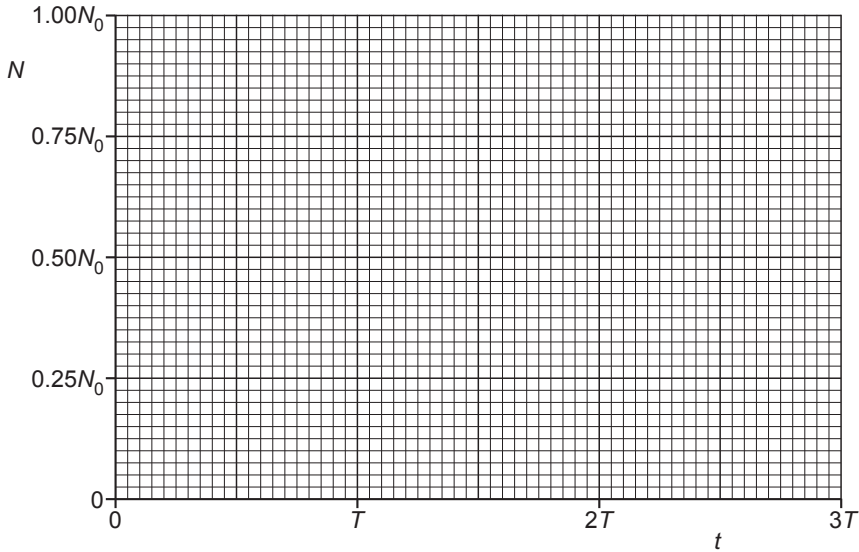


Fig. 10.1

[3]

(ii) On Fig. 10.2, sketch the variation with N of the activity A of the sample for values of N between $N = 0$ and $N = N_0$.

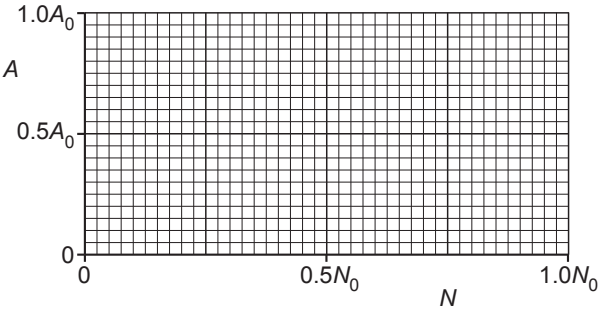


Fig. 10.2

[2]

(c) State the name of the quantity represented by the gradient of your line in:

(i) Fig. 10.1

..... [1]

(ii) Fig. 10.2.

..... [1]

(d) For the sample in (b), calculate the fraction $\frac{N}{N_0}$ at time $t = 1.70T$.

$\frac{N}{N_0} =$ [2]

[Total: 11]